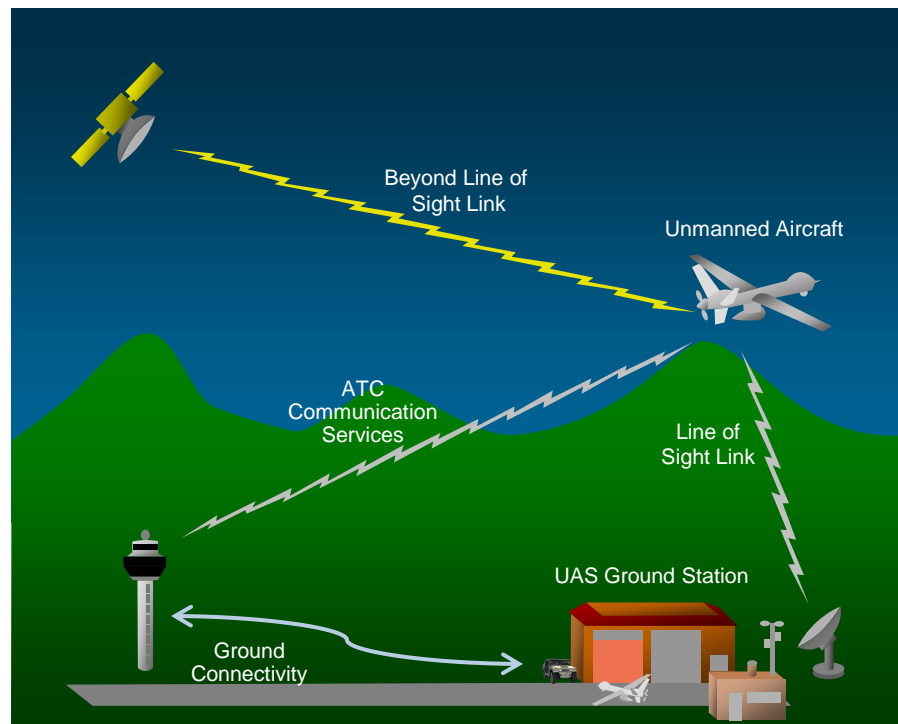




Communication



Presented by: Jim Griner
Communications Technical Lead

**Meeting of Experts on NASA's Unmanned Aircraft System (UAS) Integration
in the National Airspace Systems (NAS) Project**

Aeronautics and Space Engineering Board
National Research Council
August 5, 2010



Communication Issues

- UAS are currently managed through exceptions and are operating using DoD frequencies for line-of-sight (LOS) and satellite-based communications links, low-power LOS links in amateur bands, or unlicensed Instrument/Scientific/Medical (ISM) frequencies. None of these frequency bands are designated for Safety and Regularity of Flight.
- No radio-frequency (RF) spectrum has been allocated by the International Telecommunications Union (ITU) specifically for UAS command and control links, for either LOS or Beyond LOS (BLOS) communication.

Reliable command and control communications systems are essential for UAS operations in the NAS.



What We Heard They Wanted

RTCA SC-203, FAA Tech Center, FAA Flight Standards

- Would like NASA's assistance on spectrum studies for WRC-12.
- No work has been performed on communication security in SC-203 for the past two years, due to a lack of SMEs consistently working in this area.
- Requirements values being developed are only "seed values." They need NASA's SMEs for validating/updating these requirements based on modeling and simulation results as well as requirements validation via prototype candidate technologies.
- Requirements development has mainly focused on communication latency. They need NASA SMEs for requirements development in the areas of continuity, availability, and integrity.
- Architectures including ground based connections between UAS pilots and FAA/ATC have not been fully vetted as viable for UAS communication. This architecture may be necessary to meet current communication latency requirements. Need NASA SMEs for analysis and vetting of this architecture for compatibility with UAS and NextGen.



Prior/Ongoing Work

- NASA's communication work for the UAS Command and Control area will build upon work currently being conducted under NASA Recovery Act funds
 - Communication portions of UAS NextGen ConOps, State-of-the-Art assessment, and Gap Analysis
 - Preliminary simulations for UAS CNPC link scalability assessment
 - Surrogate UAS aircraft upgrades
- This work will also leverage FY10 in-guide funding for communication link model development



Communication Scope

- Command and Non-Payload Communication (CNPC) Spectrum for both LOS and BLOS connectivity
- CNPC Datalink
- CNPC Security
- CNPC Scalability & ATC Communication Compatibility

Not in Scope

- Changes to existing and planned FAA Communication/Navigation/Surveillance systems
- Onboard Communications & DataBus Technologies



Partnerships

- Government Agencies
 - FAA:** Sim & Modeling, Security
 - DoD:** Requirements, Standards, Performance Based Comm
 - DHS:** Requirements, Standards
- Standards/Regulatory Bodies
 - ITU-R:** Requirements, RF Compatibility/Sharing Analysis
 - RTCA SC-203:** Requirements, Security, Sim & Modeling, Validation Data
 - ASTM F38:** Requirements for Small UAS Class



RF Spectrum Objective

- **Objective 1:** Obtain appropriate frequency spectrum allocations in both the US and international frequency regulations to enable the safe and efficient operation of UAS in the NAS.
 - Rationale: Currently there are no RF spectrum allocations in either national or international frequency regulations designated for use by UAS in civilian airspace for safety-of-flight command and non-payload communication
 - Approach: Participate and contribute to the work of ITU-R Working Party 5B (the international group responsible for obtaining UAS spectrum at the next World Radio Conference in Jan/Feb 2012) by conducting compatibility/sharing analyses and providing needed data. This work will be conducted in partnership with other US government agencies (e.g. FAA, DoD, DHS) and commercial entities (e.g. UAV manufacturers) within national and international spectrum/regulatory bodies.



RF Spectrum Deliverable

- **Objective 1:**

FY	Deliverable	To	Used For
12	Compatibility/sharing studies and analyses, communication data requirements, and regulatory text	ITU Working Party 5B	Provides supporting data to obtain spectrum allocation for UAS Command and Control Communication



Datalink Objective

- **Objective 2:** Develop and validate candidate UAS CNPC system/subsystem prototype that comply with UAS international/national frequency regulations, ICAO SARPs (Standards and Recommended Practices), and FAA/RTCA MOPS/MASPS (Minimum Operational Performance Standards/Minimum Aviation System Performance Standards) for UAS
 - Rationale: UAS CNPC terrestrial and satellite systems must be designed and developed that are RF compatible with other existing or planned radio services and systems operating in the candidate spectrum bands and also meet the performance and safety requirements specified in aviation standards currently being developed for UAS in ICAO and FAA/RTCA (i.e. SARPs, MOPS, MASPs, etc).
 - Approach: Participate and contribute to regulatory/standards organizations developing frequency, safety, and performance requirements for UAS CNPC. Design prototype CNPC systems/subsystems that are compliant with these requirements through necessary technical analyses, simulations, and test measurements. Develop and test one or more prototype CNPC systems to assess performance and validate proposed system requirements. Validate performance during integrated testing with Pilot Aircraft Interface and SA/CA.



Datalink Deliverables

- **Objective 2:**

FY	Deliverable	To	Used For
12	Report on RF channel simulations and in-situ measurements	Applicable Standards/Regulatory Bodies (ITU, ICAO, NTIA, RTCA, JAUS, ASTM, etc.)	Provides technical analysis to justify and obtain permanent spectrum allocation for UAS Command and Control Communication, and validation of proposed UAS communication standards
13	Prototype CNPC system design and lab validation documentation	“	“
14	Report on prototype performance validation in a relevant environment	“	“
15	Prototype performance validation in a mixed traffic environment report	“	“



Security Objective

- **Objective 3:** Perform analysis and propose CNPC security recommendations for public/civil UAS operations
 - Rationale: Most current aviation safety voice and datalinks do not include security measures, and there has been increasing threats and vulnerabilities to both RF and network subsystems due to the ease of access to equipment and networks by the general public.
 - Approach: Participate and contribute to regulatory/standards organizations developing safety, security, and performance requirements for UAS CNPC. Perform analysis, testing, and mitigation against security risks to the confidentiality, availability, and integrity of the integrated ATC and CNPC communications systems. Propose requirements and develop architectures/standards to support these requirements. Perform integrated testing to validate performance in a relevant environment.



Security Deliverables

- **Objective 3:**

FY	Deliverable	To	Used For
11	Threat and vulnerability assessment report on RF and network systems expected to be employed in the CNPC operations	FAA	Provides supporting data for decision on UAS communication system risk acceptance vs risk mitigation
12	Risk mitigation strategy report identifying options for securely deploying a CNPC system	FAA & Standards Bodies	“
13	Prototype communications system security architecture design and laboratory validation documentation for CNPC	Applicable Standards Bodies (ITU, ICAO, RTCA, JAUS, etc)	Developing security portion of UAS communication system architecture/standards for an International environment
14	Report on prototype security architecture performance validation in a relevant environment	“	“



System Scalability Objective

- **Objective 4:** Perform analysis to support recommendations for integration of CNPC and ATC communications to ensure safe and efficient operation of UAS in the NAS
 - Rationale: Current aeronautical datalinks are separate networks providing relatively low-bandwidth with a modest number of concurrent subscribers in any given area. The introduction of UAS in the NAS has the potential to drastically increase the aeronautical traffic densities, thus dramatically increasing the data requirement for the available links.
 - Approach: Develop CNPC system link models for all UAS classes to predict performance during all phases of flight. Perform NAS-wide simulations of mixed traffic to determine CNPC and ATC communication system performance impact on air traffic delays and system capacity. Validate performance during integrated simulations and flight testing with Pilot Aircraft Interface and SA/CA.



System Scalability Deliverables

- **Objective 4:**

FY	Deliverable	To	Used For
12	Models for UAS CNPC systems	FAA	Updating models to include UAS communication system for capacity and forecast tools, used for airspace system planning and deployment
13	Report on NAS wide communication system performance utilizing candidate communication technologies	Applicable Standards/Regulatory Bodies (ICAO, RTCA, JAUS, ASTM, etc.)	Choosing UAS communication system architecture based on scalability of communication system and its impact on manned aircraft
15	Report on communication system performance impact on air traffic delays and system capacity.	FAA	Updating models to include UAS communication system for capacity and forecast tools, used for airspace system planning and deployment



Integrated Tests & Evaluation

- **Integrated Sim 1 (Year3)**

- Simulated CNPC comm and security protocols in conjunction with tactical SA algorithms to evaluate interaction between CNPC datalink and SA algorithms.

- **Integrated Flight Test 3 (Year 4)**

- One of the manned aircraft will employ the CNPC datalink and security systems, for evaluation of PAI GCS and SA/CA algorithms.

- **Integrated Flight Test 4 (Year 5)**

- Flight evaluation of an integrated PAI/NAS compliant GCS equipped with candidate CNPC datalink to assess communication latencies, RF compatibility in a relevant environment, and Separation Assurance performance



Facilities

- Wireless Communication Lab - Glenn
- Aircraft Communication Simulation Lab - Glenn
- T-34C Surrogate UAS - Glenn
- S-3B Aircraft - Glenn